Supplementary Online Materials

Stability and Change of Social and Emotional Loneliness Across the Life Span: Evidence From Two Large Scale Longitudinal Studies

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Deviations from the Preregistration

We preregistered that loneliness data from the LISS dataset would be available from 2007 to 2022. However, loneliness items were first administered in 2008 within the initial wave, resulting in one fewer measurement point than preregistered. Moreover, our original plan was to first analyze the DEAS dataset using only six-year intervals and to replicate our findings thereafter using three-year intervals. Due to issues with measurement invariance across time in the six-year dataset (DEAS-6), we decided to report only the results based on three-year intervals in the manuscript. Results on the DEAS-6 dataset together with a discussion of the measurement invariance issues are provided in the Online Supplementary Material.

Besides the planned use of Local Structural Equation Modeling (LSEM), we conducted longitudinal multilevel models with time points nested within individuals to examine whether age moderates trajectories of social and emotional loneliness over time. The rationale for this additional approach is provided in the Online Supplementary Material, along with the model equation of the longitudinal multilevel model. In addition, while we preregistered to use LOESS curves for descriptive analyses of latent retest correlations and mean levels, we did not pursue these descriptive analyses. Given the absence of statistically significant effects in all LSEM analyses, we refrained from further descriptive exploration of potential age-related patterns and instead focused on the inferential results.

Furthermore, we preregistered to use the joint estimation approach to test whether age moderates the rank-order stability and mean-level change of loneliness facets. In addition, we conducted permutation tests for the rank-order stability analyses as a complementary approach. This additional analysis was included because permutation tests are more sensitive to localized age-related variation in rank-order stability that may not be captured by global model

comparisons. Finally, we originally planned to use the Wald test (Klopp, 2020; Rosseel, 2012) to assess differences in age moderation between social and emotional loneliness. However, as we found no significant moderation effects in either model, comparisons between facets were not pursued.

A Priori Power Analysis

We conducted a simulation-based a priori power analysis for the second-order latent growth curve model. Our power analysis exclusively focused on linear slopes. For the population estimates, we utilized data from the nationally representative Netherlands Kinship Panel Study (NKPS; Dykstra et al., 2005, 2007; Hogerbrugge et al., 2014; Merz et al., 2012)[1], which assessed loneliness over four waves (N_{wave1} = 8,161) using the 11-item version of the De Jong Gierveld Loneliness Scale (de Jong-Gierveld & Kamphuis, 1985). Notably, the original validation of the 6-item version of the De Jong Gierveld Loneliness Scale was based on the first wave of the NKPS (De Jong Gierveld & van Tilburg, 2006).

Since estimating slopes requires more participants than estimating intercepts, our power analysis focused on the slopes. The complete code, along with the results of our power analysis are provided in the document "A_priori_PowerAnalysis.html" attached to the preregistration.

To achieve a statistical power of 80%, a sample size of approximately 2,800 participants for social loneliness and 2,400 participants for emotional loneliness is necessary based on the given population estimates. Given that both datasets for our main analysis contain more than four waves, we anticipate the final power to exceed these estimates.

We did not conduct a power analysis for the age moderation effects. We assume that the required sample sizes for detecting moderation effects will be higher than the sample sizes estimated in our a priori power analysis. However, since the sample sizes of the LISS dataset (N_{wave1} = 7,500) and the DEAS dataset (N_{wave1} = 4,838) are significantly larger than the estimated sample sizes, we anticipate a robust power for detecting the age moderation. This expectation is

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[1] We gratefully acknowledge the use of data from the Netherlands Kinship Panel Study (NKPS; Dykstra et al., 2005, 2007; Hogerbrugge et al., 2014).

further reinforced by the use of LSEM, which enhances power through the specification of focal points, as described earlier.

DEAS-6 Dataset

Methods

Participants, Measures and Exclusion of Focal Points

Within the DEAS-6 dataset, data from 20,714 participants was collected between 1996 and 2021. Due to missing values on all loneliness items, 3,899 participants were excluded. This resulted in a final sample of N = 16,815 participants. The mean age at study entry was 61.34 years (SD = 11.97 years; 40-93 years). The age distribution at study entry is illustrated in Figure S6 in the Online Supplementary Material (OSM). Of the participants, 49.14% identified as female and 50.86% as male. On average, participants in the DEAS-6 panel participated 1.61 times (SD = 0.88). We conducted selection bias analyses comparing levels of social loneliness, emotional loneliness, age, and gender at study entry between participants who completed only one assessment (n = 10,098) and those who completed multiple assessments (n = 6,717). Both social (d = 0.05) and emotional loneliness (d = 0.10) were significantly higher in the one-assessment group. Moreover, participants in the one-assessment group were significantly older (d = 0.34). No significant differences between groups were found for gender. Differences in social and emotional loneliness were very small, indicating no meaningful selection effects with respect to these constructs. The age difference likely reflects higher attrition among older participants, consistent with previous findings linking dropout to declining health or mortality (Chatfield et al., 2005; Mirowsky & Reynolds, 2000; Provencher et al., 2014).

Variable measurement was consistent with the procedures detailed for the DEAS dataset in the method section, as the data were drawn from the same DEAS dataset, differing only in the survey waves included. In the first two waves (i.e., 1996 and 2002), the 11-item De Jong Gierveld Loneliness Scale (de Jong-Gierveld & Kamphuis, 1985) was used to assess loneliness.

However, to ensure comparability across waves, we only used the six items included in the 6-item short version (De Jong Gierveld & van Tilburg, 2006). The means, standard deviations, and McDonald's ω for both facets, along with the zero-order correlation between the two facets at participants' first measurement point (i.e., study entry), are provided in Table S1. Based on our exclusion criteria, focal points in the DEAS-6 dataset (age range at study entry: 40–93 years) below age 41 and above age 83 were excluded.

Table S1

Means, Standard Deviations, McDonalds ω and Zero-Order Correlations of Social and Emotional Loneliness at participants' first measurement point (DEAS-6)

Facet	*M*	*SD*	McDonald's ω	r_{TI}
Social	1.84	0.65	.82	
Emotional	1.70	0.66	.77	.51***

Note. *** $p<.001$. *M* = average social and emotional loneliness at participants' first measurement point, with respective standard deviation (*SD*), and McDonald's ω. The response scale ranged from 1 to 4.

Measurement Invariance Across Time

Results from the measurement invariance analyses across time indicated that scalar measurement invariance was present for social loneliness (ΔCFI = .007, ΔRMSEA = .009). For emotional loneliness, metric invariance was supported by negligible changes in fit indices compared to the configural model (ΔCFI = .003, ΔRMSEA = .003; Chen, 2007). However, scalar invariance could not be established (ΔCFI = .047, ΔRMSEA = .022), indicating that full equality of intercepts across time was not tenable. Examination of the estimated intercepts revealed substantial deviations for one item ("I miss the pleasure of the company of others") in the 2002 and 2020 waves. Consequently, a partial scalar invariance model was specified, allowing only these two intercepts to vary freely while constraining the others. This model demonstrated acceptable overall fit (CFI = .983, RMSEA = .020, SRMR = .032) and only minor

deterioration relative to the metric model (ΔCFI = .012, ΔRMSEA = .009), supporting the assumption of partial scalar invariance and justifying cautious interpretation of latent mean differences over time (see Table S15 for all model fit indices).

It remains unclear why scalar measurement invariance across time could not be established in the emotional loneliness model of the DEAS-6 dataset. The absence of scalar invariance suggests that item intercepts vary across measurement occasions, indicating that observed scores may not be directly comparable over time at the latent level. Several explanations are conceivable. On the one hand, this pattern may reflect changes in how individuals respond to the items over time, for example due to repeated measurement effects or response shift processes. On the other hand, methodological factors may also contribute. In particular, the longitudinal structure of the DEAS-6 dataset is characterized by a substantial proportion of participants with only a single measurement occasion, resulting in a selective longitudinal subsample (see Table S14). Such selectivity and changes in sample composition across waves may affect the estimation of measurement invariance over time.

Results

Measurement Invariance Across Age

Comparison of the three increasingly restrictive LSEM models revealed that Model 3 (all latent retest covariances constrained to equality) provided the best fit for both facets (see Table S16 for model fit indices). Based on these models, we tested for measurement invariance across age using LSEM. Results indicated that scalar measurement invariance across age was present for both social (ΔCFI <.001, ΔRMSEA < .001) and emotional loneliness (ΔCFI <.001, ΔRMSEA = .001; see Table S2 for all model fit indices).

Table S2

Evaluation of Measurement Invariance and Rank-Order Stability Across Age for Social and Emotional Loneliness (DEAS-6)

Facet	Invariance model	CFI	ΔCFI	RMSEA	ΔRMSEA	SRMR
Social	Configural	.979	–	.076	–	.159
	Metric	.979	<.001	.075	.002	.159
	Scalar	.978	<.001	.074	<.001	.159
	Retest	.977	.002	.077	.002	.163
Emotional	Configural	.962	–	.093	–	.148
	Metric	.962	<.001	.091	.002	.148
	Scalar	.962	<.001	.090	.001	.148
	Retest	.960	.001	.091	.001	.150

Note. CFI = comparative fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean residual. Latent retest covariances were constrained to equality within the models.

Rank-order Stability of Social and Emotional Loneliness

Table S17 presents the means, standard deviations, and ranges of retest correlations of the loneliness facets. Building on the best-fitting LSEM models (see Table S16), we tested whether latent retest covariances of social and emotional loneliness were moderated by age using LSEM. Results of the joint estimation approach are summarized in Table S2. All models demonstrated an acceptable fit. Constraining the latent retest covariances to be equal across age did not lead to a significant deterioration in model fit for either social (ΔCFI = .002, ΔRMSEA = .002) or emotional loneliness (ΔCFI = .001, ΔRMSEA = .001).

The estimated latent retest correlations were close to zero and partly negative (range: −.16 to .05) and should be interpreted with caution. First, scalar measurement invariance across time was not supported for emotional loneliness, limiting the comparability of latent scores across measurement occasions. Second, the longitudinal structure of the dataset is characterized by a high proportion of missing data and a large number of participants with only a single measurement occasion (see Table S14), which reduces the amount of available retest information and may affect the estimation of retest correlations. In light of these limitations, we refrain from

further interpreting or visualizing the estimated retest correlations. Overall, contrary to our hypothesis, these findings consistently indicate that age does not moderate the rank-order stability of social and emotional loneliness.

Mean-level Change of Social and Emotional Loneliness

Model comparison of latent growth curve models with and without a quadratic slope showed that including the quadratic slope significantly improved the model fit for both social and emotional loneliness (see Table S18). Subsequent LSEM analyses using these latent growth curve models indicated that restricting the means of the latent intercepts and latent slopes to be equal across age did not lead to a significant deterioration of global model fit for either social (ΔCFI < .001, ΔRMSEA < .001) or emotional loneliness (ΔCFI < .001, ΔRMSEA = .001; see Table S3 for model fit indices).

Table S3

Global Model Fit of Latent Growth Curve Models Across age for Social and Emotional Loneliness (DEAS-6)

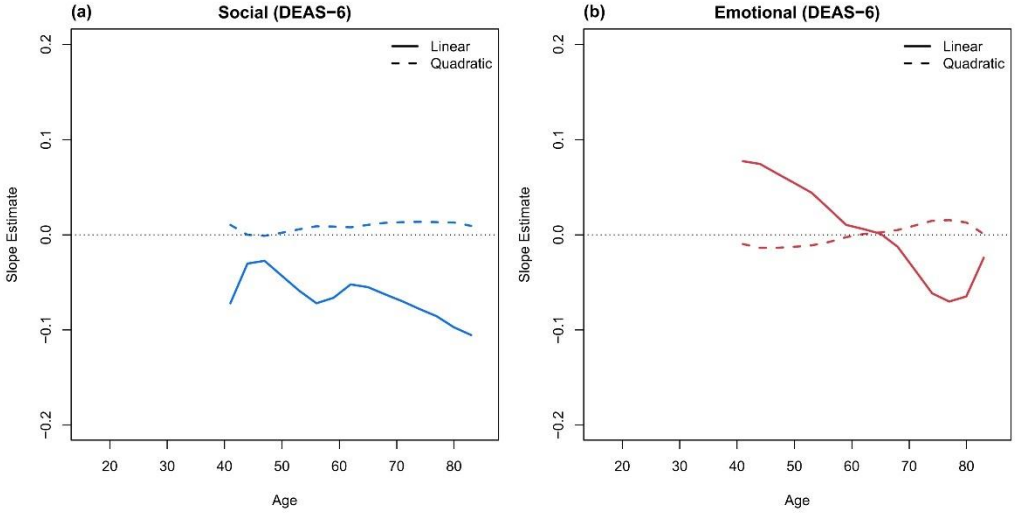
Facet	Model	CFI	ΔCFI	RMSEA	ΔRMSEA	SRMR
Social	No constraints	.997		.029		.037
	Scalar invariance	.997	<.001	.030	.001	.037
	Latent int & slopes	.997	<.001	.029	<.001	.038
Emotional	No constraints	.982		.066		.048
	Scalar invariance	.981	<.001	.064	.002	.048
	Latent int & slopes	.981	<.001	.064	<.001	.050

Note. CFI = comparative fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean residual.

Thus, the LSEM analyses found no evidence that age moderates mean-level changes in either social or emotional loneliness. Figure S3 illustrates the estimated linear and quadratic slopes of social and emotional loneliness across age, derived from LSEM models (see Figure S10 in the OSM for figures with confidence bands).

Figure S3

Latent Mean Slopes of Social and Emotional Loneliness Across the Life Span (DEAS-6 dataset)



Note. The figure displays near-zero point estimates of linear (change rates) and quadratic (changes in change rates) slopes derived from the scalar invariance model, in which the means of latent intercepts and slopes were allowed to vary as a function of age. Estimates are shown for a series of focal age points and do not represent developmental trajectories over time.

Discussion

Rank-order Stability of Social and Emotional Loneliness

Consistently with our results on rank-order stability in the LISS and DEAS dataset, we again found no significant age moderation of latent retest-correlations for either social or emotional loneliness within our LSEM analyses.

Mean-level Change of Social and Emotional Loneliness

Consistent with our results on mean-level changes in the LISS and DEAS datasets, LSEM analyses revealed no significant age moderation of mean levels across the life span for either social or emotional loneliness.

Longitudinal Multilevel Models

Methods

To complement the preregistered LSEM analyses, we conducted exploratory longitudinal multilevel models as a cross-methodological robustness check. These models similarly examined mean-level change in loneliness facets as a function of age at study entry, but were based on manifest scale scores and did not explicitly model measurement error. Specifically, we tested whether participants' age at their individual first assessment moderates trajectories of social and emotional loneliness over time.

The general model specification for the most complex model was:

$$Y_{ti} = \beta_0 + \beta_1 time_{ti} + \beta_2 time_{ti}^2 + \beta_3 age_i + \beta_4 (time_{ti} * age_i) + \beta_5 (time_{ti}^2 * age_i) + u_{0i} + u_{1i} time_{ti} + \varepsilon_{ti}$$

where u_{0i} and u_{1i} represent the random intercept and random slope for time, respectively. Time was centered at the study midpoint and age at the sample median.

Models were estimated separately for each dataset and loneliness facet. Model selection was based on nested model comparisons, including (a) linear vs. quadratic time trends, (b) models with vs. without age × time interaction terms (testing age moderation of change), and (c) models with vs. without random slopes for time. Final models were selected based on model fit comparisons. For the LISS dataset, the *bobyqa* optimizer in the lme4 package (Bates et al., 2015) was used to address convergence issues. For statistically significant interaction effects, effect sizes were quantified using quasi-R^2, defined as the proportional reduction in random slope variance attributable to the interaction (Raudenbush & Bryk, 2002).

Results

Results of the model comparisons are summarized in Table S11, whereas final model estimates, including quasi-R^2, are presented in Table S12.

Across datasets and loneliness facets, several age × time interactions reached statistical significance. However, effect sizes were consistently small to negligible (quasi-$R^2 \leq 4.47\%$), indicating that age explained only a very small proportion of interindividual differences in change over time. Overall, these findings indicate little evidence for meaningful age-related differences in trajectories of social and emotional loneliness. Although several moderation effects reached statistical significance, the corresponding effect sizes were consistently very small, suggesting that age accounted for only a negligible proportion of interindividual differences in change over time, corroborating the conclusions from the LSEM analyses.

Overall Loneliness Analyses

Measurement Invariance Across Time

For both the LISS and the DEAS dataset, results indicated that scalar measurement invariance was present for overall loneliness (see Table S4).

Table S4

Evaluation of Longitudinal Measurement Invariance for Overall Loneliness

Invariance model	χ^2	df	*p*	CFI	ΔCFI	RMSEA	ΔRMSEA	SRMR
LISS								
Configural	37210.80	2765	<.001	.880		.027		.066
Metric	37570.39	2830	<.001	.879	.001	.027	<.001	.072
Scalar	38420.97	2895	<.001	.877	.003	.027	<.001	.073
DEAS								
Configural	6727.58	335	<.001	.915		.040		.057
Metric	6787.87	355	<.001	.914	.001	.039	.001	.057
Scalar	7237.13	375	<.001	.908	.006	.039	<.001	.058

Note. Measurement invariance was established across 14 years (15 waves) for LISS and 13 years (5 waves) for DEAS; CFI = comparative fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean residual.

Measurement Invariance Across Age

The results of the preceding model comparisons are reported in Table S5. For the LISS dataset, Model 2 (latent retest covariances constrained to equality for equal time intervals) emerged as the most restrictive model without a significant loss in fit, whereas for the DEAS dataset, this was the case for Model 3 (all latent retest covariances constrained to equality).

Table S5

Evaluation of Increasingly Constrained Latent Retest-Covariances for Overall Loneliness

Model	χ^2	df	*p*	CFI	ΔCFI	RMSEA	ΔRMSEA	SRMR
LISS								
1	38420.97	2895	<.001	.877		.027		.073
2	38791.95	2972	<.001	.876	.001	.027	<.001	.078
3	42008.28	2985	<.001	.864	.011	.028	.001	.086
DEAS								
1	7237.13	375	<.001	.908		.039		.058
2	7244.27	381	<.001	.908	<.001	.038	<.001	.058
3	7373.77	384	<.001	.907	.002	.039	<.001	.062

Note. Model 1: latent retest covariances were freely estimated, Model 2: latent retest covariances with matching time intervals were constrained to quality, Model 3: all retest covariances were constrained to equality. CFI = comparative fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean residual.

Results from the joint estimation approach showed that constraining item loadings and item intercepts to equality across age did not result in a significant deterioration in model fit in both datasets (see Table S6).

Table S6

Evaluation of Measurement Invariance and Rank-Order Stability Across Age for Overall Loneliness

Invariance model	CFI	ΔCFI	RMSEA	ΔRMSEA	SRMR
LISS					
Configural	.970		.038		.063
Metric	.969	.001	.039	.001	.065
Scalar	.967	.003	.040	.001	.065
Retest	.967	<.001	.040	<.001	.095
DEAS					
Configural	.960		.067		.189
Metric	.960	<.001	.067	<.001	.189
Scalar	.958	.002	.068	.001	.189
Retest	.958	<.001	.068	<.001	.194

Note. CFI = comparative fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean residual. Latent retest covariances were constrained to equality across time points; in LISS this applied to covariances with matching intervals, in DEAS to all retest covariances.

Across datasets, changes in CFI and RMSEA remained within predefined criteria (ΔCFI < .01; ΔRMSEA < .015), supporting scalar invariance across age. SRMR values were elevated across all LSEM models of the DEAS dataset but remained stable across model specifications, indicating that this index did not reflect a significant deterioration in model fit.

Rank-order Stability of Overall Loneliness

Table S7 presents the means, standard deviations, and ranges of retest correlations of the loneliness facets in the LISS and DEAS datasets. Across datasets, constraining latent retest covariances to equality across age did not lead to a significant deterioration in model fit (ΔCFI <.010; ΔRMSEA <.015). Thus, the joint estimation approach found no evidence that age moderates rank-order stability in overall loneliness. Figure S4 illustrates 3-year latent retest correlations in overall loneliness across the life span.

Table S7

Latent Retest-Correlations of Overall Loneliness Across Age Using LSEM

(a)

Overall	***M(cov)***	***M(r)***	***SD(r)***	**Range(*r*)**
08-09	.315	.705	0.042	.658 – .789
08-10	.261	.564	0.049	.489 – .630
08-11	.217	.502	0.068	.355 – .571
08-13	.146	.322	0.072	.154 – .401
08-14	.115	.240	0.076	.074 – .324
08-15	.088	.197	0.081	.016 – .289
08-16	.065	.144	0.080	-.032 – .234
08-17	.043	.089	0.075	-.072 – .177
08-18	.022	.048	0.075	-.105 – .133
08-19	.003	.004	0.068	-.138 – .082
08-20	-.022	-.052	0.058	-.195 – .014
08-21	-.039	-.094	0.051	-.242 – -.039
08-22	-.074	-.159	0.040	-.291 – -.127
09-10	.315	.691	0.045	.629 – .758
09-11	.261	.612	0.067	.472 – .687
09-13	.179	.403	0.073	.235 – .487
09-14	.146	.309	0.078	.137 – .398
09-15	.115	.261	0.086	.073 – .362

Table S7 (continued)

Overall	*M(cov)*	*M(r)*	*SD(r)*	Range(*r*)
09-16	.088	.203	0.084	.015 – .299
09-17	.065	.139	0.079	-.030 – .233
09-18	.043	.099	0.081	-.069 – .195
09-19	.022	.049	0.074	-.099 – .136
09-20	.003	.005	0.065	-.131 – .082
09-21	-.022	-.054	0.060	-.206 – .016
09-22	-.039	-.086	0.043	-.195 – -.037
10-11	.315	.720	0.057	.624 – .796
10-13	.217	.476	0.069	.330 – .554
10-14	.179	.371	0.076	.217 – .457
10-15	.146	.323	0.085	.141 – .421
10-16	.115	.257	0.085	.072 – .356
10-17	.088	.186	0.080	.015 – .282
10-18	.065	.146	0.082	-.030 – .243
10-19	.043	.095	0.079	-.067 – .189
10-20	.022	.046	0.070	-.096 – .130
10-21	.003	.005	0.066	-.135 – .084
10-22	-.022	-.048	0.053	-.161 – .014
11-13	.261	.616	0.071	.460 – .693
11-14	.217	.484	0.083	.308 – .572
11-15	.179	.428	0.093	.225 – .530
11-16	.146	.352	0.092	.142 – .452
11-17	.115	.261	0.089	.072 – .367
11-18	.088	.217	0.092	.015 – .322
11-19	.065	.156	0.087	-.029 – .256
11-20	.043	.099	0.081	-.066 – .195
11-21	.022	.053	0.078	-.103 – .146
11-22	.003	.005	0.065	-.122 – .083
13-14	.315	.681	0.060	.580 – .754
13-15	.261	.602	0.079	.450 – .695
13-16	.217	.507	0.080	.325 – .595
13-17	.179	.394	0.079	.228 – .491
13-18	.146	.345	0.089	.141 – .445
13-19	.115	.268	0.088	.072 – .368
13-20	.088	.197	0.084	.015 – .294
13-21	.065	.151	0.085	-.030 – .250
13-22	.043	.091	0.075	-.067 – .178
14-15	.315	.690	0.080	.568 – .786
14-16	.261	.577	0.079	.427 – .665
14-17	.217	.453	0.081	.305 – .551
14-18	.179	.402	0.089	.213 – .504
14-19	.146	.322	0.087	.132 – .421

Table S7 (continued)

Overall	*M(cov)*	*M(r)*	*SD*	Range(*r*)
14-20	.115	.244	0.085	.066 – .344
14-21	.088	.197	0.086	.014 – .298
14-22	.065	.131	0.074	-.028 – .219
15-16	.315	.749	0.080	.600 – .839
15-17	.261	.584	0.086	.447 – .691
15-18	.217	.524	0.098	.318 – .636
15-19	.179	.426	0.093	.222 – .532
15-20	.146	.332	0.092	.137 – .440
15-21	.115	.276	0.096	.071 – .389
15-22	.088	.192	0.083	.015 – .290
16-17	.315	.716	0.068	.608 – .797
16-18	.261	.638	0.088	.451 – .735
16-19	.217	.523	0.088	.321 – .621
16-20	.179	.414	0.089	.222 – .516
16-21	.146	.354	0.094	.141 – .462
16-22	.115	.254	0.084	.071 – .352
17-18	.315	.728	0.076	.608 – .820
17-19	.261	.594	0.078	.450 – .690
17-20	.217	.474	0.085	.318 – .579
17-21	.179	.411	0.090	.227 – .521
17-22	.146	.304	0.078	.140 – .401
18-19	.315	.775	0.077	.605 – .851
18-20	.261	.615	0.088	.444 – .715
18-21	.217	.539	0.097	.323 – .646
18-22	.179	.404	0.082	.224 – .501
19-20	.315	.734	0.071	.596 – .806
19-21	.261	.639	0.085	.452 – .731
19-22	.217	.484	0.074	.320 – .574
20-21	.315	.742	0.077	.601 – .828
20-22	.261	.560	0.065	.443 – .640
21-22	.315	.715	0.053	.609 – .774

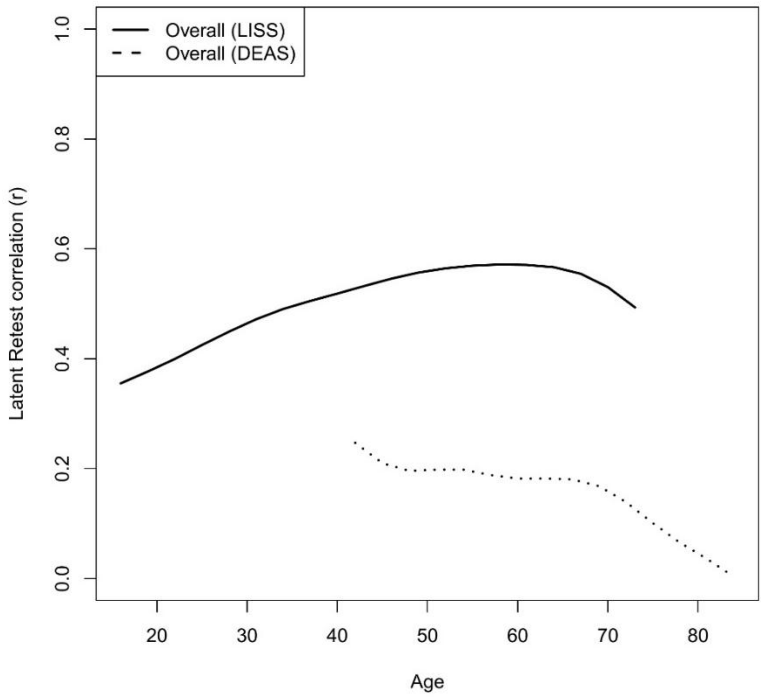
(b)

Overall	*M(cov)*	*M(r)*	*SD(r)*	Range(*r*)
08-11	.144	.160	0.054	.004 – .247
08-14	.144	.149	0.051	.003 – .196
08-17	.144	.158	0.053	.004 – .223
08-20	.144	.162	0.052	.006 – .227
11-14	.144	.176	0.061	.004 – .265
11-17	.144	.188	0.065	.005 – .302
11-20	.144	.192	0.063	.007 – .308
14-17	.144	.174	0.060	.004 – .239
14-20	.144	.178	0.058	.006 – .244
17-20	.144	.190	0.061	.008 – .277

Note. Panels (a) and (b) refer to the LISS and DEAS datasets, respectively. Interval labels (e.g., 96–02) refer to measurement intervals (e.g., 1996–2002). *M(cov)* = average retest covariance across age, *M(r)* = average retest correlation across age, with respective standard deviation (*SD*) derived from LSEM analysis with joint estimation (scalar invariance model).

Figure S4

Three-Year Latent Retest Correlations of Overall Loneliness Across the Life Span



Note. Estimates represent 2008–2011 latent retest correlations derived from the scalar invariance model, in which retest covariances were allowed to vary as a function of participants' age at their first assessment point.

Mean-level Change of Overall Loneliness

Model comparison of latent growth curve models with and without a quadratic slope showed that including the quadratic slope significantly improved the model fit in the LISS ($\chi^2(1) = 3.88$, $p = .049$) and the DEAS dataset ($\chi^2(4) = 37.12$, $p < .001$). Subsequent LSEM analyses using these latent growth curve models indicated that restricting the means of the latent intercepts and latent slopes to be equal across age did not lead to a significant deterioration of global model fit (see Table S8 for model fit indices). SRMR values were elevated across all LSEM models of the LISS dataset but remained stable across model specifications, indicating that this index did not reflect a significant deterioration in model fit.

Table S8

Global Model Fit of Latent Growth Curve Models Across age for Overall Loneliness

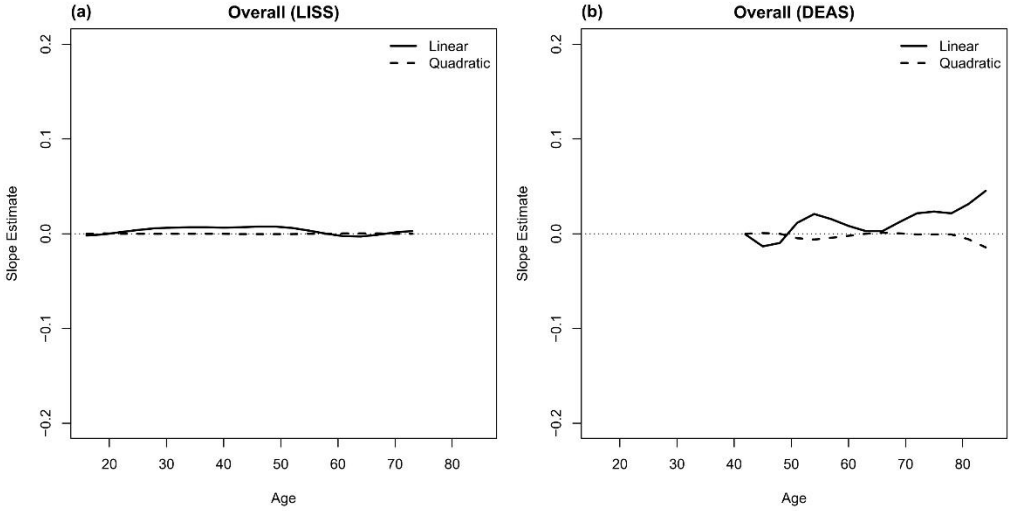
Model	CFI	ΔCFI	RMSEA	ΔRMSEA	SRMR
LISS					
No constraints	.952		.048		.135
Scalar invariance	.949	.003	.049	.001	.135
Latent int & slopes	.949	<.001	.049	<.001	.135
DEAS					
No constraints	.972		.056		.062
Scalar invariance	.970	.002	.057	.001	.063
Latent int & slopes	.970	<.001	.057	<.001	.063

Note. CFI = comparative fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean residual.

Thus, the joint estimation approach found no evidence that age moderates mean-level changes in overall loneliness. Figure S5 illustrates the estimated linear and quadratic slopes of overall loneliness across age, derived from LSEM models.

Figure S5

Latent Mean Slopes of Overall Loneliness Across the Life Span



Note. The figure displays near-zero point estimates of linear (change rates) and quadratic (changes in change rates) slopes derived from the scalar invariance model, in which the means of latent intercepts and slopes were allowed to vary as a function of age. Estimates are shown for a series of focal age points and do not represent developmental trajectories over time.

Longitudinal Multilevel Models

Results of the model comparisons are summarized in Table S9, whereas final model estimates, including quasi-R^2, are presented in Table S10.

Table S9

Model Comparisons of Longitudinal Multilevel Models

Model Comparison	χ^2	***df***	***p***
LISS			
(a) Linear vs. Quadratic	1.00	1	.317
(b) Age x Time	7.66	1	.006
(c) Random Slope	3183.7	2	<.001
DEAS			
(a) Linear vs. Quadratic	1.81	1	.179
(b) Age x Time	46.90	1	<.001
(c) Random Slope	130.89	2	<.001

Note. Model comparisons (χ^2 tests) for longitudinal multilevel models examining trajectories of overall.

Table S10

Fixed Effect Estimates from Linear Mixed Effects Models for Overall Loneliness

Effect	**Estimate**	***SE***	***p***	***quasi-R²* (%)**
LISS				
Intercept	1.335	0.003	<.001	–
Time	<-0.001	0.000	.985	–
Age	-0.001	0.000	<.001	–
Age × Time	<-0.001	0.000	.005	0.05
DEAS				
Intercept	1.771	0.005	<.001	–
Time	0.011	0.002	<.001	–
Age	-0.002	0.000	<.001	–
Age × Time	0.001	0.000	<.001	3.20

Note. Estimates are unstandardized fixed effects from linear mixed-effects models. SE = standard error. Quasi-R^2 indicates the proportional reduction in random slope variance attributable to age at participants' first measurement point.

For both datasets the age × time interactions reached statistical significance. For the LISS dataset, the effect size was negligible (quasi-R^2 = 0.05%), indicating that age explained only a very small proportion of interindividual differences in change over time. For the DEAS dataset, quasi-R^2 could not be computed because models including a random slope for time did not converge.

References

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, *67*(1). https://doi.org/10.18637/jss.v067.i01

Buecker, S., Denissen, J. J. A., & Luhmann, M. (2021). A propensity-score matched study of changes in loneliness surrounding major life events. *Journal of Personality and Social Psychology*, *121*(3), 669–690. https://doi.org/10.1037/pspp0000373

Chatfield, M. D., Brayne, C. E., & Matthews, F. E. (2005). A systematic literature review of attrition between waves in longitudinal studies in the elderly shows a consistent pattern of dropout between differing studies. *Journal of Clinical Epidemiology*, *58*(1), 13–19. https://doi.org/10.1016/j.jclinepi.2004.05.006

Chen, F. F. (2007). Sensitivity of goodness of fit indexes to lack of measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal*, *14*(3), 464–504. https://doi.org/10.1080/10705510701301834

De Jong Gierveld, J., & van Tilburg, T. (2006). A 6-item scale for overall, emotional, and social loneliness: Confirmatory tests on survey data. *Research on Aging*, *28*(5), 582–598. https://doi.org/10.1177/0164027506289723

de Jong-Gierveld, J., & Kamphuis, F. (1985). The development of a Rasch-type loneliness scale. *Applied Psychological Measurement*, *9*(3), 289–299. https://doi.org/10.1177/014662168500900307

Dittmann-Kohli, F., Kohli, M., Künemund, H., Motel, A., Steinleitner, C., Westerhof, G., & with the infas Sozialforschung. (1997). Übersetzung ins Deutsche durch DEAS-Projekt / Translation into German by DEAS project. In Forschungsgruppe Altern und Lebenslauf [Research Group on Aging and the Life Course] (Ed.), *Lebenszusammenhänge, Selbst- und Lebenskonzeptionen—Erhebungsdesign und Instrumente des Alters-Surveys [Life*

contexts, conceptions of self and life—Survey Design and Instruments of the German Ageing Survey]. Freie Universität Berlin.

Dykstra, P. A., Kalmijn, M., Knijn, T. C. M., Komter, A. E., Liefbroer, A., & Mulder, C. H. (2005). *Codebook of the Netherlands Kinship Panel Study, a multi-actor, multi-method panel study on solidarity in family relationships, Wave 1. NKPS Working Paper No. 4* [Data set]. Netherlands Interdisciplinary Demographic Institute.

Dykstra, P. A., Kalmijn, M., Knijn, T. C. M., Komter, A. E., Liefbroer, A., & Mulder, C. H. (2007). *Codebook of the Netherlands Kinship Panel Study: A multi-actor, multi-method panel study on solidarity in family relationships, wave 2. NKPS Working Paper No 6* [Data set]. Netherlands Interdisciplinary Demographic Institute.

Hogerbrugge, M. J. A., de Hoon, S., Dykstra, P. A., Komter, A. E., Liefbroer, A., & Mulder, C. H. (2014). *Codebook of the Netherlands Kinship Panel Study, a multi-actor, multi-method panel study on solidarity in family relationships, Wave 4. NKPS Working Paper No. 13* [Data set]. Netherlands Interdisciplinary Demographic Institute.

Klopp, E. (2020). A tutorial on testing the equality of standardized regression coefficients in structural equation models using Wald tests with lavaan. *The Quantitative Methods for Psychology*, *16*(4), 315–333. https://doi.org/10.20982/tqmp.16.4.p315

Merz, E.-M., Dykstra, P. A., Hogerbrugge, M. J. A., Komter, A. E., Liefbroer, A., & Mulder, C. H. (2012). *Codebook of the Netherlands Kinship Panel Study, a multi-actor, multi-method panel study on solidarity in family relationships, Wave 3. NKPS Working Paper No. 10* [Data set]. Netherlands Interdisciplinary Demographic Institute.

Mirowsky, J., & Reynolds, J. R. (2000). Age, depression, and attrition in the National Survey of Families and Households. *Sociological Methods & Research*, *28*(4), 476–504. https://doi.org/10.1177/0049124100028004004

Provencher, V., Mortenson, W. B., Tanguay-Garneau, L., Bélanger, K., & Dagenais, M. (2014). Challenges and strategies pertaining to recruitment and retention of frail elderly in research studies: A systematic review. *Archives of Gerontology and Geriatrics*, *59*(1), 18–24. https://doi.org/10.1016/j.archger.2014.03.006

Raudenbush, S., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd edn). SAGE Publications, Incorporated.

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, *48*(2), 1–36. https://doi.org/https://doi.org/10.18637/jss.v048.i02

Table S11

Model Comparisons of Longitudinal Multilevel Models

Facet	Model Comparison	χ^2	*df*	*p*
LISS				
Social	(a) Linear vs. Quadratic	2.96	1	.086
	(b) Age x Time	1.58	1	.209
	(c) Random Slope	1965.6	2	<.001
Emotional	(a) Linear vs. Quadratic	0.00	1	.984
	(b) Age x Time	15.59	1	<.001
	(c) Random Slope	2317.4	2	<.001
DEAS				
Social	(a) Linear vs. Quadratic	5.77	1	.016
	(b) Age x Time	15.99	2	<.001
	(c) Random Slope	84.43	2	<.001
Emotional	(a) Linear vs. Quadratic	18.2	1	<.001
	(b) Age x Time	55.66	2	<.001
	(c) Random Slope	109.1	2	<.001
DEAS-6				
Social	(a) Linear vs. Quadratic	12.75	1	<.001
	(b) Age x Time	10.81	2	.005
	(c) Random Slope	–	–	–
Emotional	(a) Linear vs. Quadratic	37.13	1	<.001
	(b) Age x Time	38.21	2	<.001
	(c) Random Slope	–	–	–

Note. Model comparisons (χ^2 tests) for longitudinal multilevel models examining trajectories of social and emotional loneliness. For the DEAS-6 dataset, random slopes for time could not be estimated, precluding the last model comparison.

Table S12

Fixed Effect Estimates from Linear Mixed Effects Models for Social and Emotional Loneliness

Facet	Effect	Estimate	*SE*	*p*	*quasi-R²* (%)
LISS					
Social	Intercept	1.406	0.004	<.001	–
	Time	-0.002	0.000	<.001	–
	Age	0.001	0.001	<.001	–
Emotional	Intercept	1.264	0.003	<.001	–
	Time	0.002	0.000	<.001	–
	Age	-0.002	0.000	<.001	–
	Age × Time	0.000	0.000	<.001	0.05
DEAS					
Social	Intercept	1.802	0.006	<.001	–
	Time	-0.003	0.002	0.157	–
	Time²	-0.003	0.002	.030	–
	Age	-0.002	0.001	.002	–
	Age × Time	0.001	0.000	<.001	0.91
	Age × Time²	0.000	0.000	.697	–
Emotional	Intercept	1.732	0.006	<.001	–
	Time	0.026	0.002	<.001	–
	Time²	0.008	0.002	<.001	–
	Age	-0.002	0.001	<.001	–
	Age × Time	0.002	0.000	<.001	4.47
	Age × Time²	0.000	0.000	.313	–
DEAS-6					
Social	Intercept	1.819	0.006	< .001	–
	Time	-0.025	0.003	< .001	–
	Time²	0.008	0.002	< .001	–
	Age	-0.002	0.001	< .001	–
	Age × Time	0.000	0.000	.139	–
	Age × Time²	0.001	0.000	.004	–
Emotional	Intercept	1.687	0.006	< .001	–
	Time	0.042	0.003	< .001	–
	Time²	0.014	0.002	< .001	–
	Age	-0.003	0.001	< .001	–
	Age × Time	0.000	0.000	.187	–
	Age × Time²	0.001	0.000	< .001	–

Note. Estimates are unstandardized fixed effects from linear mixed-effects models. SE = standard error. Quasi-R^2 indicates the proportional reduction in random slope variance attributable to age at participants' first measurement point.

Table S13

Participants by Wave Participation

	LISS		DEAS		DEAS-6	
Participations	n	n cumulative	n	n cumulative	n	n cumulative
14	1413	1413				
13	379	1792				
12	504	2296				
11	270	2566				
10	501	3067				
9	594	3661				
8	594	4255				
7	505	4760				
6	1011	5771				
5	766	6537	1162	1162	182	182
4	1173	7710	1148	2310	535	717
3	1932	9642	2572	4882	1841	2558
2	2305	11947	2391	7273	4159	6717
1	4785	16732	4894	12167	10098	16815

Note. The first column refers to the number of waves, the second column indicates the number of participants who engaged in the corresponding number of waves, and the third column reflects the total number of participants who took part in at least that many waves. As the 2012 wave of the LISS dataset was excluded due to inconsistencies in the response format of the loneliness items compared to other waves (Buecker et al., 2021), the maximum number of waves is 14 instead of 15.

Table S14

Overview of Loneliness Measures Across LISS, DEAS, and DEAS-6

Aspect	LISS Panel	DEAS Panel	DEAS-6 Panel
Instrument	De Jong Gierveld Loneliness Scale (6-item short version)	De Jong Gierveld Loneliness Scale (6-item, German adaptation)	De Jong Gierveld Loneliness Scale (6-item, German adaptation; short version derived from 11-item version in early waves)
Source	De Jong Gierveld & van Tilburg (2006)	De Jong Gierveld & van Tilburg (2006); Dittmann-Kohli et al. (1997)	De Jong Gierveld & van Tilburg (2006); de Jong-Gierveld & Kamphuls (1985); Dittmann-Kohli et al. (1997)
Number of items	6	6	6
Facet structure	3 social (positively worded) 3 emotional (negatively worded)	3 social (positively worded) 3 emotional (negatively worded)	3 social (positively worded) 3 emotional (negatively worded)
Example social item	"I know a lot of people that I can fully rely on"	"Ich kenne viele Menschen, auf die ich mich wirklich verlassen kann"	Same as DEAS
Example emotional item	"I have a sense of emptiness around me"	"Ich vermisse Leute, bei denen ich mich wohlfühle"	Same as DEAS
Response scale	3-point: 1 = Yes 2 = More or less 3 = No	4-point: 1 = Strongly agree 2 = Agree 3 = Disagree 4 = Strongly disagree	Same as DEAS
Coding direction	Recoded so that higher values indicate higher loneliness	Recoded so that higher values indicate higher loneliness	Recoded so that higher values indicate higher loneliness
Measurement waves	2008, 2009, 2010, 2011, 2012 (excluded), 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022	2008, 2011, 2014, 2017, 2020	1996, 2002, 2008, 2014, 2020
Reliability (ω)	~ .78–.89	~ .75–.82	~ .77–.82

Note. The DEAS-6 dataset is based on the same panel as DEAS but includes a different selection of waves. In the first two waves, the full 11-item version of the De Jong Gierveld Loneliness Scale was administered; however, for comparability across waves, only the six items corresponding to the 6-item short version were used in all analyses.

Table S15

Evaluation of Longitudinal Measurement Invariance for Social and Emotional Loneliness

Facet	Invariance model	χ^2	df	*p*	CFI	ΔCFI	RMSEA	ΔRMSEA	SRMR
LISS									
Social	Configural	636.51	455	<.001	.999		.005		.013
	Metric	696.88	481	<.001	.998	<.001	.005	<.001	.014
	Scalar	1031.69	507	<.001	.996	.002	.008	.003	.015
Emotional	Configural	1024.82	455	<.001	.996		.009		.014
	Metric	1181.88	481	<.001	.995	.001	.009	.001	.016
	Scalar	1485.54	507	<.001	.993	.002	.011	.001	.017
DEAS									
Social	Configural	95.97	50	<.001	.999		.009		.011
	Metric	104.15	58	<.001	.999	<.001	.008	.001	.013
	Scalar	121.73	66	<.001	.999	<.001	.008	<.001	.014
Emotional	Configural	89.44	50	<.001	.999		.008		.012
	Metric	111.08	58	<.001	.998	.001	.009	.001	.014
	Scalar	480.80	66	<.001	.985	.013	.023	.014	.023
DEAS-6									
Social	Configural	77.65	50	.007	.999		.006		.017
	Metric	91.69	58	.003	.999	<.001	.006	<.001	.017
	Scalar	310.78	66	<.001	.992	.007	.015	.009	.021
Emotional	Configural	106.19	50	<.001	.998		.008		.024
	Metric	179.66	58	<.001	.995	.003	.011	.003	.029
	Scalar	1291.53	66	<.001	.948	.047	.033	.022	.048
	Partial scalar[a]	466.84	60	<.001	.983	.012	.020	.009	.004

Note. Measurement invariance was established across 14 years (15 waves) for LISS, 13 years (5 waves) for DEAS, and 25 years (5 waves) for DEAS-6; [a]for emotional loneliness, the ΔCFI and ΔRMSEA values in the partial scalar row refer to the differences between the metric model and the partial scalar model; CFI = comparative fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean residual.

Table S16

Evaluation of Increasingly Constrained Latent Retest-Covariances for Social and Emotional Loneliness

Facet	Model	χ^2	df	*p*	CFI	ΔCFI	RMSEA	ΔRMSEA	SRMR
LISS									
Social	1	1031.69	507	<.001	.996		.008		.015
	2	1335.24	584	<.001	.994	.002	.009	.001	.037
	3	3129.79	597	<.001	.981	.013	.016	.007	.057
Emotional	1	1485.54	507	<.001	.993		.011		.017
	2	1865.62	584	<.001	.991	.002	.011	.001	.04
	3	4447.22	597	<.001	.973	.018	.02	.008	.065
DEAS									
Social	1	121.73	66	<.001	.999		.008		.014
	2	127.62	72	<.001	.999	<.001	.008	<.001	.016
	3	217.63	75	<.001	.996	.002	.013	.005	.029
Emotional	1	480.80	66	<.001	.985		.023		.023
	2	493.82	72	<.001	.985	<.001	.022	.001	.025
	3	592.71	75	<.001	.982	.003	.024	.002	.035
DEAS-6									
Social	1	310.78	66	<.001	.992		.015		.021
	2	338.84	72	<.001	.992	.001	.015	<.001	.034
	3	371.03	75	<.001	.991	.001	.015	<.001	.042
Emotional	1	491.84	64	<.001	.982		.020		.033
	2	513.03	70	<.001	.981	.001	.019	.001	.039
	3	541.42	73	<.001	.980	.001	.020	<.001	.044

Note. Model 1: latent retest covariances were freely estimated, Model 2: latent retest covariances with matching time intervals were constrained to quality, Model 3: all retest covariances were constrained to equality. CFI = comparative fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean residual.

Table S17

Latent Retest-Correlations of Social and Emotional Loneliness Across Age Using LSEM

(a)

Social	***M(cov)***	***M(r)***	***SD(r)***	**Range(*r*)**	**Pointwise *p*-value**
08-09	.364	.705	0.037	.648 – .767	18-46; 53-74
08-10	.303	.574	0.021	.539 – .607	16-38; 46-71
08-11	.254	.519	0.012	.499 – .537	16-33; 41-69; 75
08-13	.173	.347	0.020	.302 – .375	16-31; 36-65; 70-75
08-14	.139	.264	0.024	.201 – .291	16-32; 37-65; 69-75
08-15	.108	.22	0.035	.135 – .254	16-31; 36-63; 68-75
08-16	.081	.168	0.043	.059 – .204	16-30; 35-62; 67-75
08-17	.057	.111	0.046	-.012 – .154	16-30; 35-61; 66-75
08-18	.034	.07	0.054	-.081 – .117	16-29; 34-60; 66-75
08-19	.012	.024	0.056	-.131 – .072	16-29; 34-59; 65-75
08-20	-.016	-.033	0.053	-.192 – .015	16-28; 34-59; 64-75
08-21	-.036	-.076	0.051	-.243 – -.029	16-26; 35-58; 63-75
08-22	-.076	-.144	0.042	-.290 – -.108	37-56; 62-75
09-10	.364	.695	0.023	.663 – .737	16-40; 47-72
09-11	.303	.622	0.02	.587 – .654	16-36; 42-70
09-13	.211	.428	0.018	.378 – .447	16-32; 38-66; 71-75
09-14	.173	.335	0.024	.276 – .363	16-33; 38-65; 69-75
09-15	.139	.287	0.034	.207 – .326	16-32; 37-64; 69-75
09-16	.108	.227	0.040	.131 – .264	16-31; 36-63; 67-75
09-17	.081	.163	0.044	.055 – .206	16-31; 36-62; 66-75
09-18	.057	.122	0.052	-.012 – .171	16-30; 35-61; 66-75
09-19	.034	.072	0.055	-.077 – .121	16-29; 34-60; 65-75
09-20	.012	.024	0.054	-.126 – .073	16-29; 34-59; 65-75
09-21	-.016	-.033	0.054	-.199 – .016	16-28; 34-58; 64-75
09-22	-.036	-.07	0.045	-.199 – -.027	16-27; 35-58; 64-75
10-11	.364	.721	0.027	.694 – .774	16-38; 45-74
10-13	.254	.498	0.011	.468 – .513	16-33; 39-68; 73-75
10-14	.211	.395	0.018	.353 – .421	16-34; 39-66; 71-75
10-15	.173	.347	0.028	.279 – .381	16-33; 38-65; 69-75
10-16	.139	.282	0.034	.201 – .316	16-32; 37-64; 68-75
10-17	.108	.210	0.037	.121 – .249	16-32; 37-63; 67-75
10-18	.081	.170	0.047	.058 – .214	16-31; 35-62; 67-75
10-19	.057	.118	0.05	-.012 – .166	16-30; 35-61; 66-75
10-20	.034	.068	0.052	-.073 – .116	16-30; 35-60; 65-75
10-21	.012	.025	0.055	-.129 – .075	16-29; 34-59; 65-75
10-22	-.016	-.03	0.048	-.161 – .014	16-28; 34-59; 64-75
11-13	.303	.628	0.023	.578 – .664	16-34; 41-71
11-14	.254	.505	0.022	.453 – .535	16-35; 39-69; 73-75
11-15	.211	.450	0.029	.370 – .486	16-34; 39-67; 71-75
11-16	.173	.375	0.034	.282 – .409	16-32; 37-65; 69-75

Table S17 (continued)

Social	*M(cov)*	*M(r)*	*SD(r)*	Range(*r*)	Pointwise *p*-value
11-17	.139	.286	0.036	.206 – .327	16-33; 37-64; 68-75
11-18	.108	.240	0.046	.130 – .285	16-31; 36-63; 67-75
11-19	.081	.180	0.051	.061 – .226	16-31; 35-62; 67-75
11-20	.057	.122	0.053	-.013 – .174	16-31; 35-61; 66-75
11-21	.034	.076	0.058	-.085 – .129	16-30; 34-60; 65-75
11-22	.012	.025	0.054	-.118 – .073	16-29; 34-59; 65-75
13-14	.364	.692	0.030	.663 – .748	16-38; 44-74
13-15	.303	.619	0.028	.569 – .659	16-36; 41-71
13-16	.254	.529	0.021	.466 – .553	16-33; 38-68; 73-75
13-17	.211	.420	0.021	.371 – .451	16-34; 38-65; 70-75
13-18	.173	.371	0.034	.282 – .407	16-31; 36-64; 69-75
13-19	.139	.296	0.038	.204 – .331	16-31; 36-63; 68-75
13-20	.108	.224	0.041	.128 – .264	16-31; 36-63; 67-75
13-21	.081	.176	0.049	.062 – .222	16-31; 35-62; 67-75
13-22	.057	.114	0.048	-.011 – .159	16-30; 35-61; 66-75
14-15	.364	.701	0.044	.652 – .764	16-39; 43-74
14-16	.303	.593	0.030	.544 – .637	16-37; 41-70; 75
14-17	.254	.478	0.021	.450 – .512	16-36; 40-67; 72-75
14-18	.211	.427	0.029	.354 – .465	16-34; 38-67; 71-75
14-19	.173	.349	0.032	.269 – .383	16-33; 37-65; 69-75
14-20	.139	.272	0.035	.193 – .312	16-33; 37-64; 68-75
14-21	.108	.222	0.042	.123 – .265	16-32; 37-63; 67-75
14-22	.081	.154	0.042	.048 – .195	16-31; 36-62; 66-75
15-16	.364	.755	0.045	.683 – .815	16-38; 42-75
15-17	.303	.601	0.033	.565 – .651	16-38; 41-69
15-18	.254	.545	0.035	.464 – .590	16-35; 39-69; 74-75
15-19	.211	.451	0.032	.365 – .489	16-34; 38-66; 71-75
15-20	.173	.360	0.035	.276 – .404	16-34; 38-65; 69-75
15-21	.139	.302	0.042	.201 – .351	16-33; 37-64; 68-75
15-22	.108	.218	0.040	.118 – .257	16-32; 36-62; 67-75
16-17	.364	.724	0.032	.688 – .766	16-38; 42-75
16-18	.303	.650	0.037	.565 – .696	16-36; 40-70
16-19	.254	.546	0.029	.462 – .575	16-34; 38-67; 72-75
16-20	.211	.441	0.030	.361 – .477	16-34; 38-66; 70-75
16-21	.173	.379	0.038	.278 – .420	16-33; 37-65; 69-75
16-22	.139	.281	0.036	.189 – .315	16-32; 37-63; 67-75
17-18	.364	.737	0.037	.691 – .790	16-38; 42-75
17-19	.303	.612	0.026	.568 – .652	16-36; 40-67
17-20	.254	.502	0.025	.462 – .541	16-36; 39-66; 72-75
17-21	.211	.436	0.029	.367 – .478	16-35; 38-65; 70-75
17-22	.173	.332	0.028	.257 – .364	16-33; 37-63; 67-75
18-19	.364	.782	0.041	.687 – .830	16-35; 40-75

Table S17 (continued)

Social	***M(cov)***	***M(r)***	***SD (r)***	**Range(*r*)**	**Pointwise *p*-value**
18-20	.303	.634	0.037	.561 – .681	16-36; 40-70
18-21	.254	.560	0.036	.464 – .602	16-34; 38-68; 74-75
18-22	.211	.431	0.025	.368 – .457	16-33; 38-64; 69-75
19-20	.364	.750	0.035	.680 – .790	16-36; 40-74
19-21	.303	.655	0.035	.564 – .694	16-35; 39-69
19-22	.254	.512	0.020	.459 – .536	16-33; 38-64; 69-75
20-21	.364	.756	0.043	.679 – .818	16-37; 41-75
20-22	.303	.585	0.015	.553 – .610	16-36; 39-66; 71-75
21-22	.364	.726	0.015	.698 – .745	16-36; 41-67
Emotional	***M(cov)***	***M(r)***	***SD(r)***	**Range(*r*)**	**Pointwise *p*-value**
08-09	.289	.699	0.040	.658 – .782	19-47; 55-75
08-10	.239	.558	0.046	.489 – .623	16-38; 45-71
08-11	.198	.496	0.065	.362 – .563	16-34; 41-70; 75
08-13	.133	.319	0.069	.160 – .396	16-31; 37-65; 71-75
08-14	.105	.237	0.074	.076 – .322	16-33; 38-65; 69-75
08-15	.081	.196	0.080	.022 – .288	16-32; 37-64; 69-75
08-16	.060	.146	0.078	-.028 – .236	16-30; 36-62; 67-75
08-17	.041	.092	0.074	-.068 – .181	16-30; 36-61; 66-75
08-18	.021	.052	0.074	-.098 – .140	16-30; 35-61; 66-75
08-19	.004	.008	0.065	-.122 – .088	16-29; 35-60; 66-75
08-20	-.019	-.046	0.054	-.174 – .022	16-27; 35-59; 64-75
08-21	-.034	-.087	0.047	-.226 – -.031	16-23; 35-57; 64-75
08-22	-.064	-.149	0.037	-.273 – -.114	39-54; 62-75
09-10	.289	.686	0.042	.628 – .750	16-41; 48-73
09-11	.239	.605	0.065	.477 – .678	16-36; 42-71
09-13	.163	.399	0.070	.242 – .482	16-33; 39-66; 72-75
09-14	.133	.306	0.076	.140 – .394	16-33; 38-65; 70-75
09-15	.105	.259	0.085	.075 – .359	16-33; 38-64; 69-75
09-16	.081	.203	0.083	.021 – .301	16-31; 37-63; 68-75
09-17	.060	.140	0.077	-.026 – .235	16-31; 37-62; 67-75
09-18	.041	.103	0.080	-.064 – .201	16-30; 36-61; 66-75
09-19	.021	.053	0.074	-.093 – .144	16-30; 35-61; 66-75
09-20	.004	.009	0.062	-.113 – .086	16-29; 35-60; 65-75
09-21	-.019	-.049	0.057	-.187 – .024	16-28; 35-59; 65-75
09-22	-.034	-.080	0.041	-.185 – -.029	16-24; 35-57; 64-75
10-11	.289	.714	0.055	.626 – .788	16-36; 44-73
10-13	.198	.471	0.066	.334 – .548	16-34; 41-68; 73-75
10-14	.163	.366	0.073	.220 – .451	16-35; 39-66; 71-75
10-15	.133	.319	0.083	.143 – .415	16-34; 38-65; 70-75
10-16	.105	.256	0.084	.076 – .355	16-33; 38-64; 69-75
10-17	.081	.186	0.079	.020 – .283	16-32; 37-63; 67-75
10-18	.060	.148	0.081	-.025 – .246	16-31; 36-62; 67-75
10-19	.041	.099	0.078	-.063 – .194	16-30; 36-61; 66-75

Table S17 (continued)

Emotional	*M(cov)*	*M(r)*	*SD(r)*	Range(*r*)	Pointwise *p*-value
10-20	.021	.049	0.068	-.088 – .135	16-30; 36-61; 66-75
10-21	.004	.010	0.064	-.117 – .091	16-29; 35-60; 65-75
10-22	-.019	-.043	0.050	-.148 – .022	16-28; 36-59; 65-75
11-13	.239	.609	0.069	.461 – .684	16-35; 42-71
11-14	.198	.477	0.082	.307 – .565	16-35; 39-69; 73-75
11-15	.163	.421	0.091	.227 – .521	16-35; 39-67; 72-75
11-16	.133	.349	0.089	.145 – .448	16-32; 37-65; 70-75
11-17	.105	.258	0.088	.074 – .365	16-33; 38-64; 68-75
11-18	.081	.217	0.092	.020 – .324	16-31; 36-63; 68-75
11-19	.060	.157	0.086	-.025 – .259	16-31; 36-62; 67-75
11-20	.041	.101	0.079	-.060 – .198	16-31; 36-61; 66-75
11-21	.021	.057	0.077	-.091 – .154	16-30; 36-61; 66-75
11-22	.004	.010	0.062	-.108 – .089	16-29; 35-60; 65-75
13-14	.289	.672	0.059	.573 – .744	16-36; 45-74
13-15	.239	.594	0.078	.446 – .687	16-37; 42-72
13-16	.198	.502	0.078	.327 – .591	16-34; 40-68; 73-75
13-17	.163	.387	0.078	.230 – .486	16-35; 40-65; 71-75
13-18	.133	.342	0.088	.144 – .442	16-32; 37-65; 70-75
13-19	.105	.266	0.087	.074 – .367	16-32; 37-63; 68-75
13-20	.081	.194	0.082	.019 – .292	16-32; 37-63; 68-75
13-21	.060	.153	0.083	-.025 – .253	16-31; 36-62; 67-75
13-22	.041	.094	0.073	-.060 – .183	16-30; 36-61; 66-75
14-15	.289	.678	0.079	.554 – .774	16-38; 42-74
14-16	.239	.570	0.078	.424 – .658	16-37; 41-70; 75
14-17	.198	.444	0.081	.301 – .545	16-37; 40-67; 72-75
14-18	.163	.397	0.088	.214 – .498	16-35; 39-67; 71-75
14-19	.133	.318	0.085	.133 – .417	16-33; 38-64; 69-75
14-20	.105	.237	0.084	.067 – .338	16-34; 38-64; 69-75
14-21	.081	.197	0.085	.019 – .300	16-32; 37-63; 68-75
14-22	.060	.131	0.073	-.022 – .220	16-31; 36-62; 67-75
15-16	.289	.740	0.080	.593 – .831	16-38; 43-75
15-17	.239	.572	0.087	.438 – .682	16-38; 41-69
15-18	.198	.515	0.099	.314 – .629	16-36; 40-69; 74-75
15-19	.163	.419	0.092	.223 – .525	16-35; 39-67; 72-75
15-20	.133	.322	0.091	.135 – .429	16-34; 38-65; 70-75
15-21	.105	.273	0.095	.072 – .388	16-34; 38-64; 69-75
15-22	.081	.192	0.082	.019 – .291	16-32; 37-63; 68-75
16-17	.289	.706	0.069	.601 – .791	16-39; 42-73
16-18	.239	.631	0.088	.449 – .729	16-37; 41-70
16-19	.198	.517	0.088	.321 – .616	16-35; 39-67; 73-75
16-20	.163	.402	0.088	.221 – .505	16-35; 39-66; 71-75
16-21	.133	.351	0.093	.144 – .460	16-33; 38-64; 69-75
16-22	.105	.252	0.084	.071 – .352	16-33; 37-63; 68-75

Table S17 (continued)

Emotional	*M(cov)*	*M(r)*	*SD(r)*	Range(*r*)	Pointwise *p*-value
17-18	.289	.716	0.079	.596 – .814	16-38; 42-74
17-19	.239	.583	0.080	.444 – .682	16-37; 41-67
17-20	.198	.456	0.087	.308 – .566	16-37; 40-67; 72-75
17-21	.163	.404	0.089	.228 – .516	16-36; 40-65; 70-75
17-22	.133	.299	0.079	.136 – .398	16-34; 38-64; 68-75
18-19	.289	.766	0.08	.597 – .845	16-36; 41-75
18-20	.239	.595	0.092	.431 – .701	16-37; 41-70
18-21	.198	.531	0.098	.322 – .643	16-36; 40-68; 74-75
18-22	.163	.398	0.083	.219 – .496	16-34; 39-65; 70-75
19-20	.289	.711	0.077	.577 – .791	16-37; 41-75
19-21	.239	.631	0.086	.449 – .726	16-36; 40-70
19-22	.198	.476	0.076	.308 – .567	16-35; 39-65; 71-75
20-21	.289	.719	0.082	.583 – .811	16-37; 42-75
20-22	.239	.540	0.072	.416 – .626	16-36; 40-67; 73-75
21-22	.289	.703	0.059	.583 – .767	16-37; 41-69

(b)

Social	*M(cov)*	*M(r)*	*SD(r)*	Range(*r*)	Pointwise *p*-value
08-11	.162	.168	0.054	.008 – .257	42-67; 72-84
08-14	.162	.155	0.050	.007 – .202	42-68; 72-84
08-17	.162	.166	0.052	.010 – .230	42-68; 72-84
08-20	.162	.171	0.050	.014 – .237	42-68; 72-84
11-14	.162	.184	0.061	.008 – .277	42-68; 72-84
11-17	.162	.197	0.064	.011 – .316	42-67; 72-84
11-20	.162	.204	0.062	.016 – .325	42-59; 65-66; 72-84
14-17	.162	.183	0.059	.010 – .248	42-68; 72-84
14-20	.162	.188	0.057	.014 – .255	42-68; 72-84
17-20	.162	.202	0.059	.019 – .291	42-59; 66-67; 72-84
Emotional	***M(cov)***	***M(r)***	***SD(r)***	**Range(*r*)**	**Pointwise *p*-value**
08-11	.132	.153	0.053	.001 – .229	42-68; 72-84
08-14	.132	.140	0.049	.001 – .184	42-68; 72-84
08-17	.132	.149	0.052	.001 – .205	42-68; 72-84
08-20	.132	.151	0.051	.002 – .207	42-68; 72-84
11-14	.132	.164	0.059	.001 – .240	42-68; 72-84
11-17	.132	.176	0.062	.002 – .268	42-68; 72-84
11-20	.132	.178	0.061	.002 – .271	42-59; 61-67; 72-84
14-17	.132	.160	0.057	.001 – .215	42-68; 72-84
14-20	.132	.162	0.056	.002 – .217	42-68; 72-84

(c)

Social	***M(cov)***	***M(r)***	***SD(r)***	**Range(*r*)**
96-02	-.042	-.066	0.063	-.152 – .048
96-08	-.042	-.061	0.060	-.150 – .050
96-14	-.042	-.056	0.055	-.140 – .049
96-20	-.042	-.069	0.071	-.205 – .056
02-08	-.042	-.059	0.058	-.155 – .051
02-14	-.042	-.054	0.053	-.145 – .049
02-20	-.042	-.066	0.069	-.211 – .056
08-14	-.042	-.050	0.051	-.143 – .051
08-20	-.042	-.062	0.066	-.209 – .059
14-20	-.042	-.056	0.061	-.194 – .057
Emotional	***M(cov)***	***M(r)***	***SD(r)***	**Range(*r*)**
96-02	-.043	-.080	0.057	-.162 – .013
96-08	-.043	-.070	0.051	-.150 – .013
96-14	-.043	-.065	0.046	-.138 – .012
96-20	-.043	-.077	0.059	-.191 – .014
02-08	-.043	-.070	0.051	-.163 – .013
02-14	-.043	-.064	0.047	-.154 – .012
02-20	-.043	-.077	0.060	-.213 – .013
08-14	-.043	-.057	0.042	-.139 – .011
08-20	-.043	-.068	0.054	-.193 – .013

Note. Panels (a), (b), and (c) refer to the LISS, DEAS, and DEAS-6 datasets, respectively. Interval labels (e.g., 96–02) refer to measurement intervals (e.g., 1996–2002). *M(cov)* = average retest covariance across age, *M(r)* = average retest correlation across age, with respective standard deviation (*SD*) derived from LSEM analysis with joint estimation (scalar invariance model). Pointwise *p*-values indicate the age ranges where the estimated retest correlation statistically deviates from the average retest correlation across the entire sample age span ($p < .05$). Significant deviations were determined using a permutation test with focal points specified at one-year intervals. Permutation tests were performed only for the datasets presented in the main manuscript (LISS and DEAS). Therefore, these estimates are not reported for the DEAS-6 dataset.

Table S18

Robust Chi-Square Difference Tests Comparing Linear and Quadratic Growth Models

Facet	$\Delta\chi^2$	Δdf	p	Preferred model
LISS				
Social	1.17	1	.280	Linear
Emotional	10.66	1	.001	Quadratic
DEAS				
Social	20.39	4	< .001	Quadratic
Emotional	40.82	4	< .001	Quadratic
DEAS-6				
Social	23.30	4	< .001	Quadratic
Emotional	9.98	4	.041	Quadratic

Note. $\Delta\chi^2$ based on Satorra–Bentler scaled difference tests.

Table S19

Summary of Local Structural Equation Modeling Results

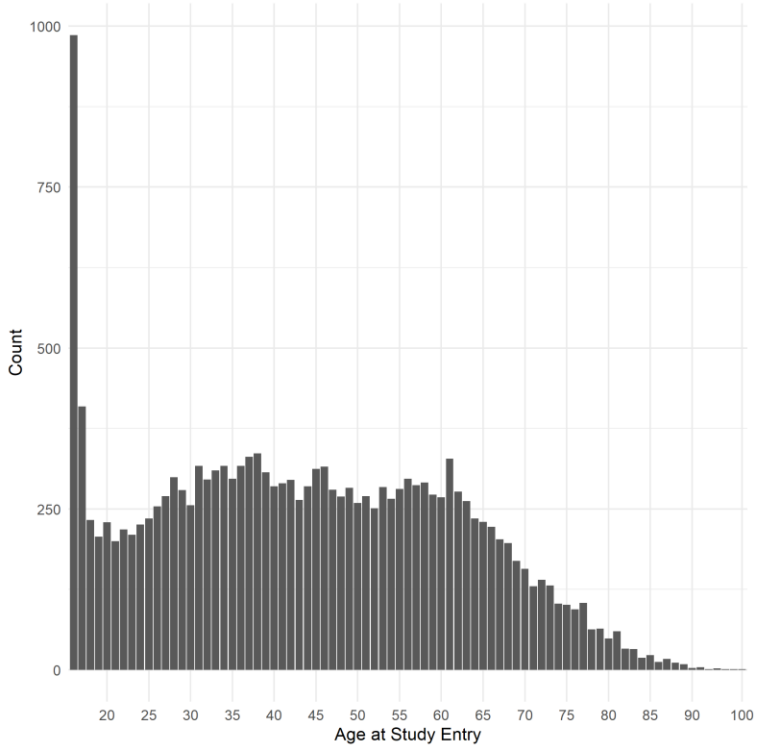
Rank-order Stability		
Facet	**Final Estimated Model**	**Joint Estimation Approach Results**
LISS		
Social	Model 2	No age moderation
Emotional	Model 2	No age moderation
DEAS		
Social	Model 3	No age moderation
Emotional	Model 3	No age moderation
DEAS-6		
Social	Model 3	No age moderation
Emotional	Model 3	No age moderation
Mean-level Change		
Facet	**Final Estimated Model**	**Joint Estimation Approach Results**
LISS		
Social	Quadratic LGCM	No age moderation
Emotional	Quadratic LGCM	No age moderation
DEAS		
Social	Linear LGCM	No age moderation
Emotional	Quadratic LGCM	No age moderation
DEAS-6		
Social	Quadratic LGCM	No age moderation
Emotional	Quadratic LGCM	No age moderation

Note. Rank-order stability is based on latent retest covariance models selecting the best-fitting model per dataset (Model 1: no equality constraints; Model 2: equality constraints across equal intervals; Model 3: full equality constraints). Mean-level change is based on second-order latent growth curve models (LGCM) selecting linear vs. quadratic specifications via chi-square difference tests. The joint estimation approach tested for age moderation of model parameters. Across all models, no evidence for age moderation was found.

Figure S6

Age Distribution at Study Entry

(a)



(b)

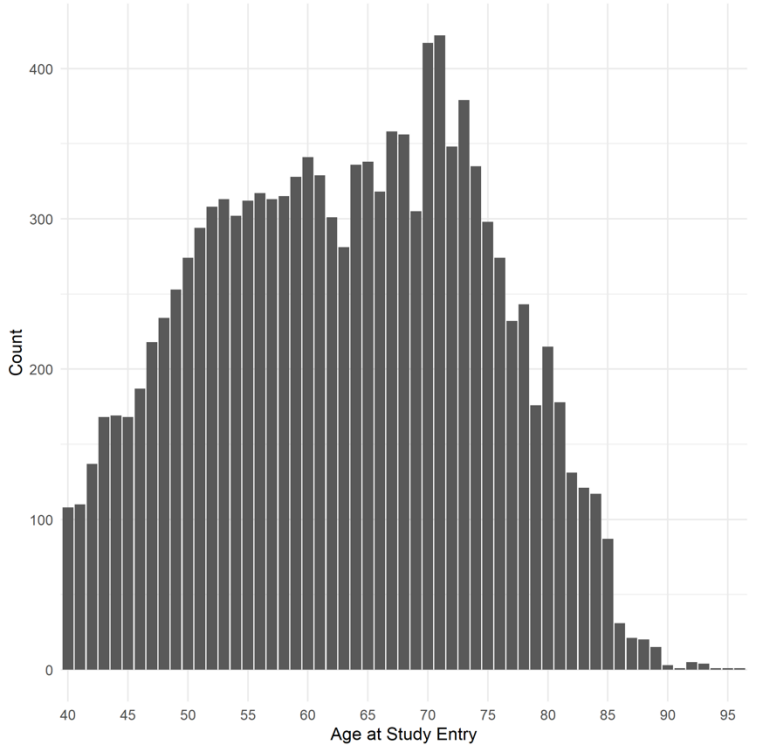
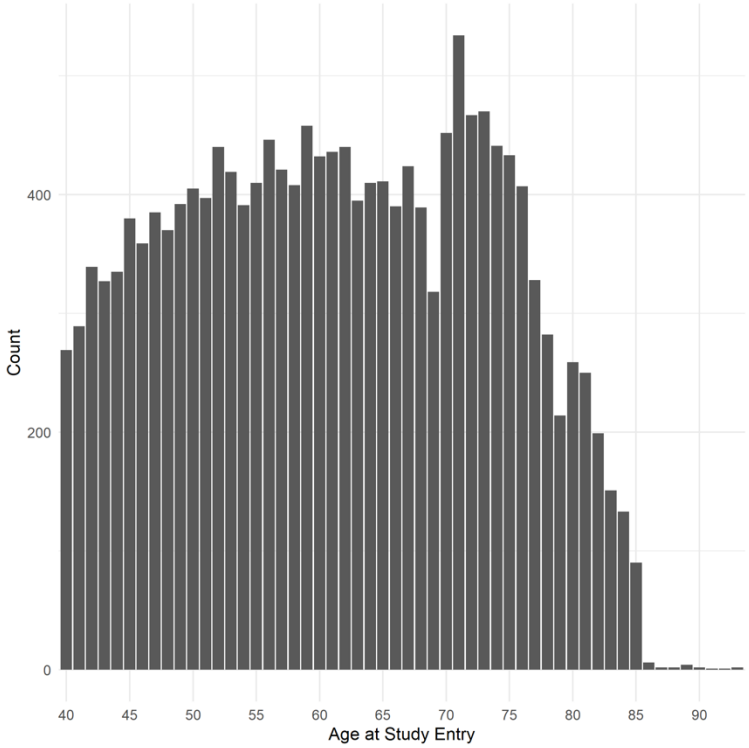


Figure S6 (continued)

(c)

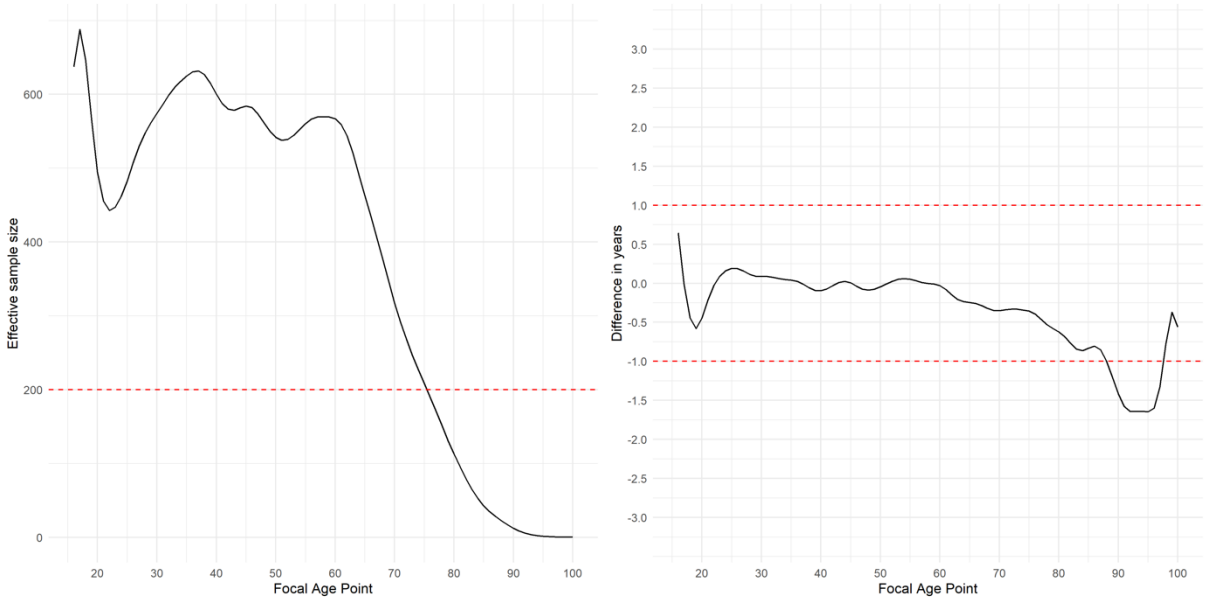


Note. Age-distribution at study entry for the LISS (a), DEAS (b) and DEAS-6 (c) dataset. The x-axis represents participants' age at the first measurement point (T1), while the y-axis shows the number of participants at each age.

Figure S7

Exclusion Criteria for Focal Points

(a)



(b)

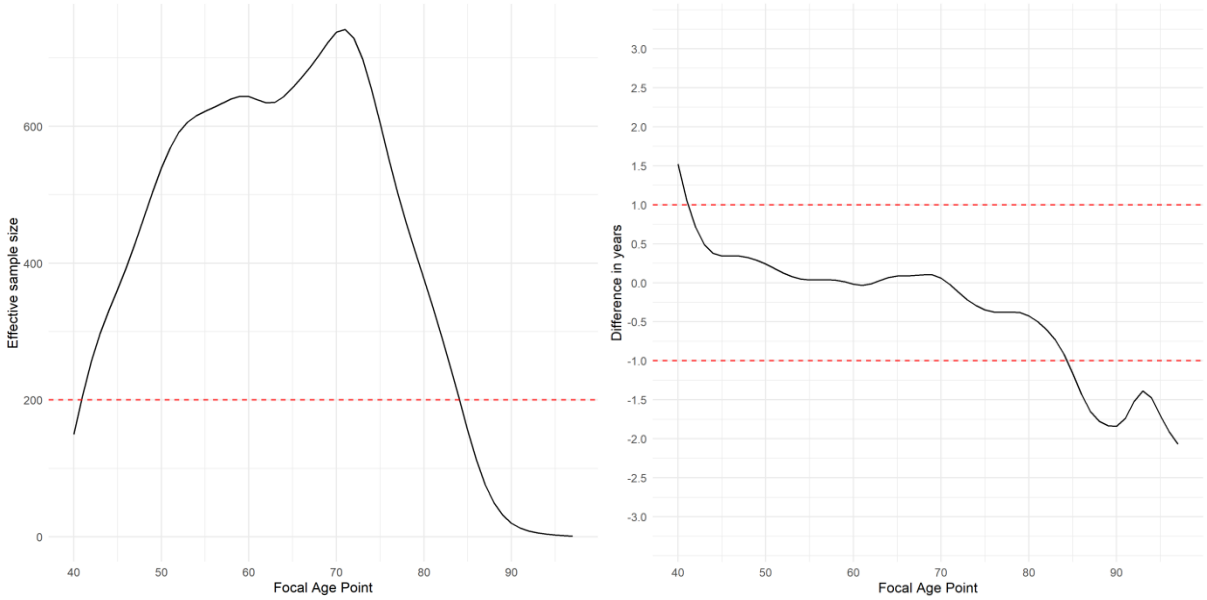
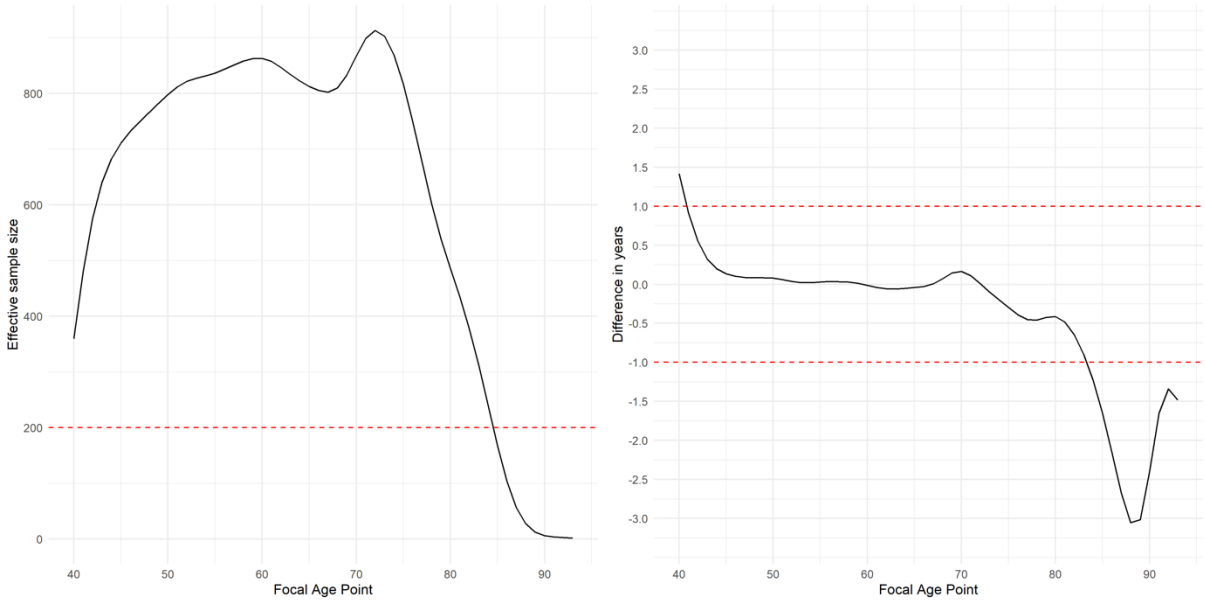


Figure S7 (continued)

(c)

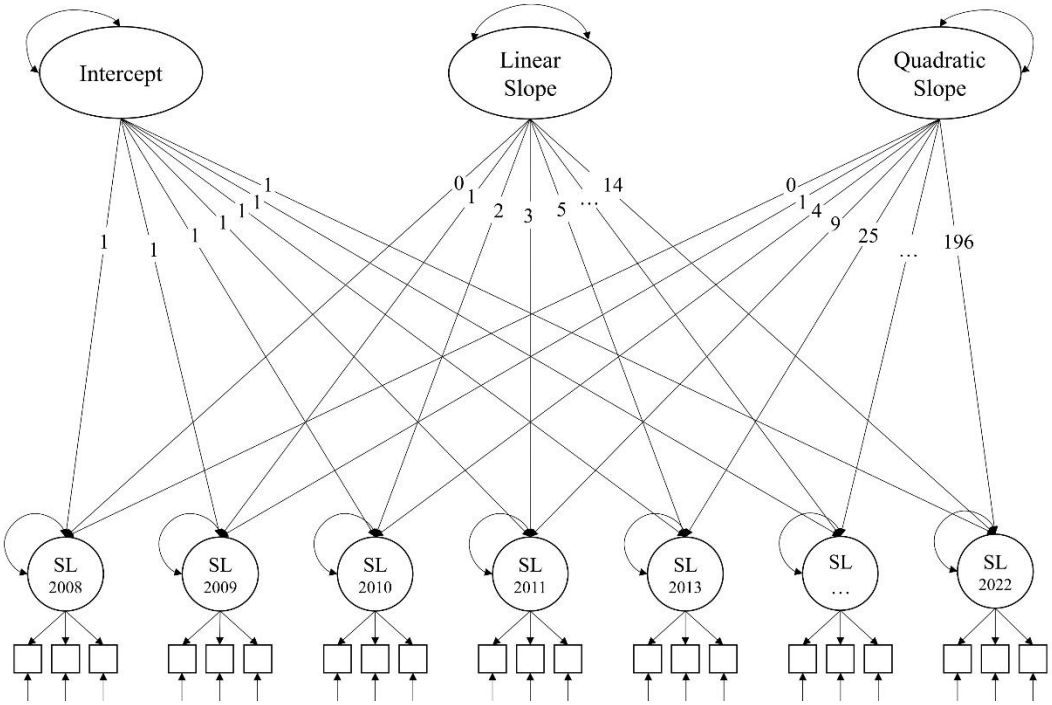


Note. Focal points were excluded if the sum of weights is below $N = 200$ (left figure), or the target age deviates more than 1 year from the weighted mean age (right figure). The red dashed line indicates the cut-off for each criteria. Illustrated are the figures for the LISS (a), DEAS (b), and DEAS-6 (c) dataset.

Figure S8

Second-Order Latent Growth Curve Models (Larger Versions)

(a)



(b)

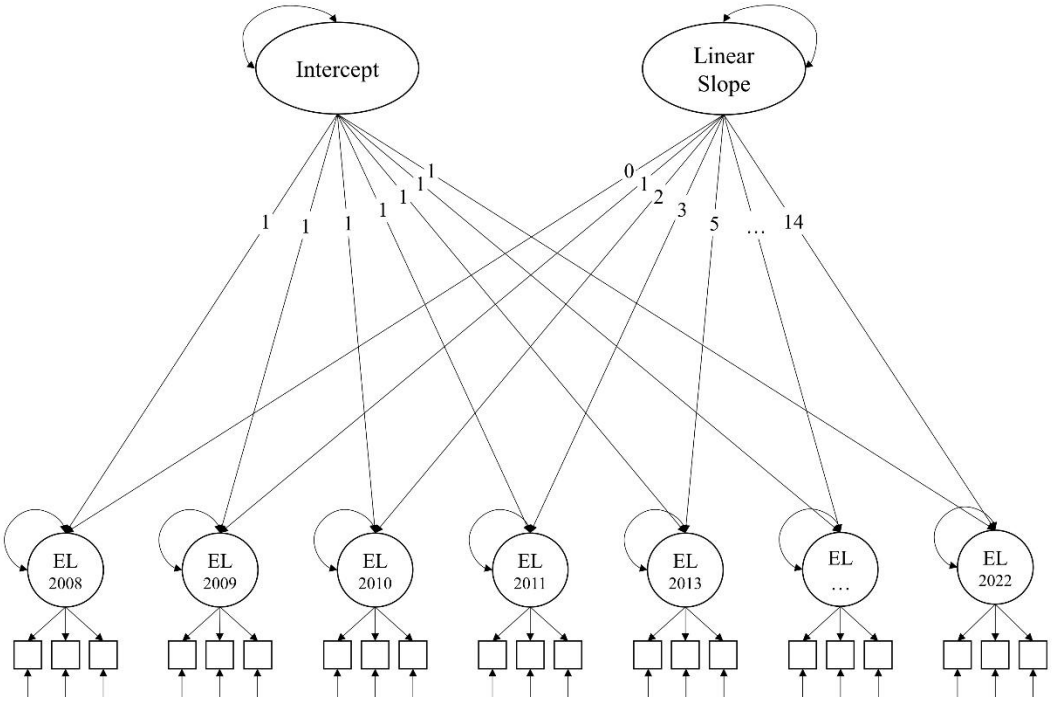
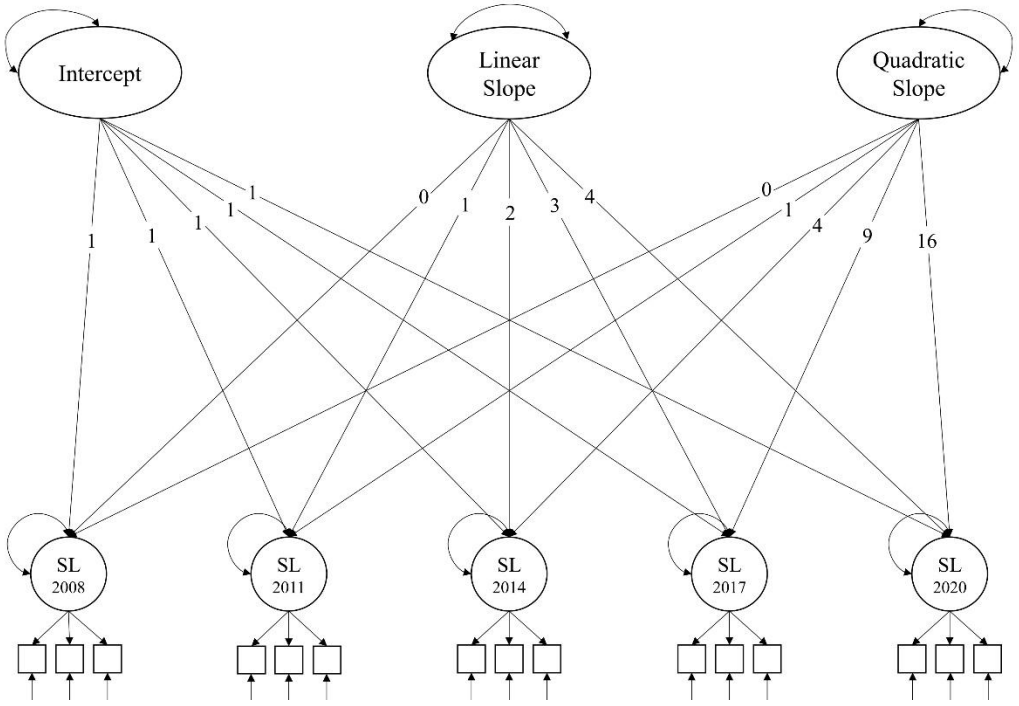
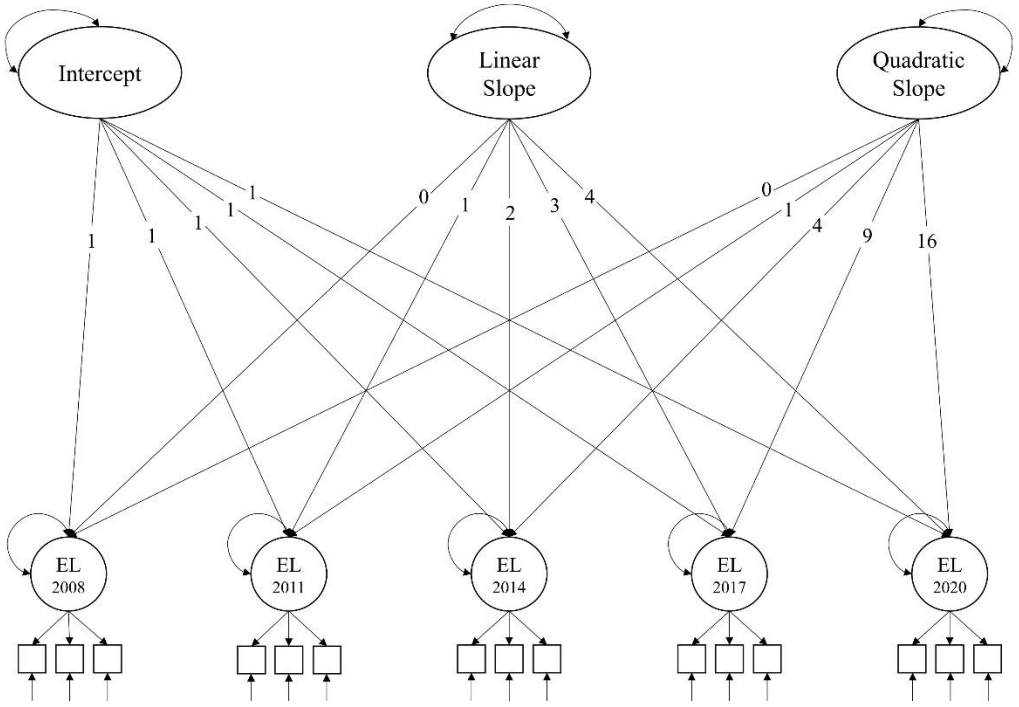


Figure S8 (continued)

(c)



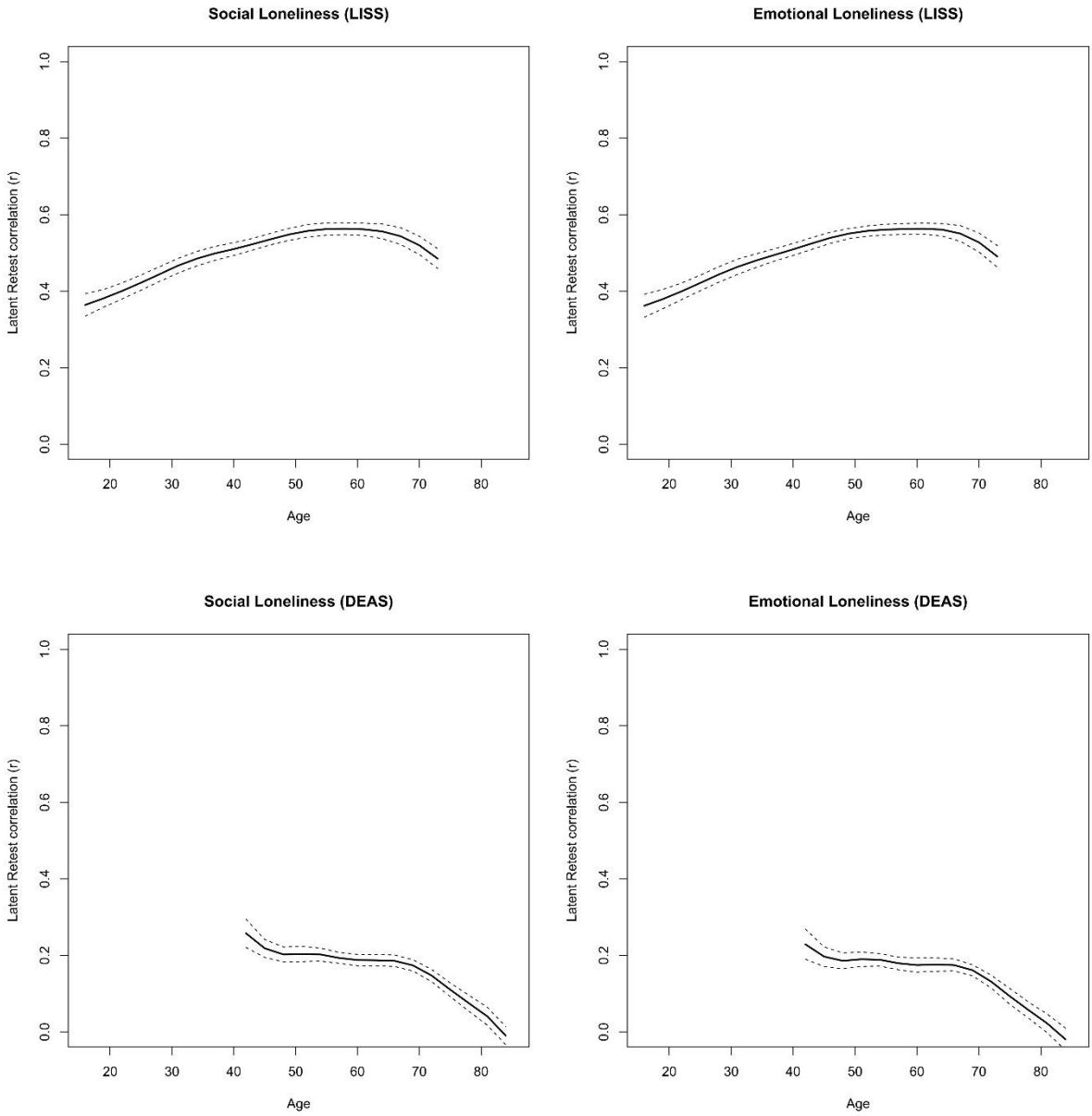
(d)



Note. Second-order latent growth curve models of (a) social (SL) and (b) emotional loneliness (EL) for the LISS dataset, and (c) social and (d) emotional loneliness for the DEAS and DEAS-6 dataset. Rectangles reflect De Jong Gierveld Loneliness Scale items to assess loneliness at each wave (e.g., 2008). For clarity, residual covariances of same-worded items over time are not displayed.

Figure S9

Latent Retest Correlations of Social and Emotional Loneliness Across the Life Span with Confidence Bands



Note. Estimates represent 2008–2011 latent retest correlations derived from the scalar invariance model, in which retest covariances were allowed to vary as a function of participants' age at their individual first assessment in the LISS and DEAS dataset. Estimates for the DEAS-6 dataset are not shown, as they were close to zero and partly negative (range: −.16 to .05) and should be interpreted with caution due to methodological limitations. Solid lines depict point estimates; dashed lines indicate 95% confidence intervals (±1.96 SE).

Figure S10

Latent Mean Slopes of Social and Emotional Loneliness Across the Life Span with Confidence Bands

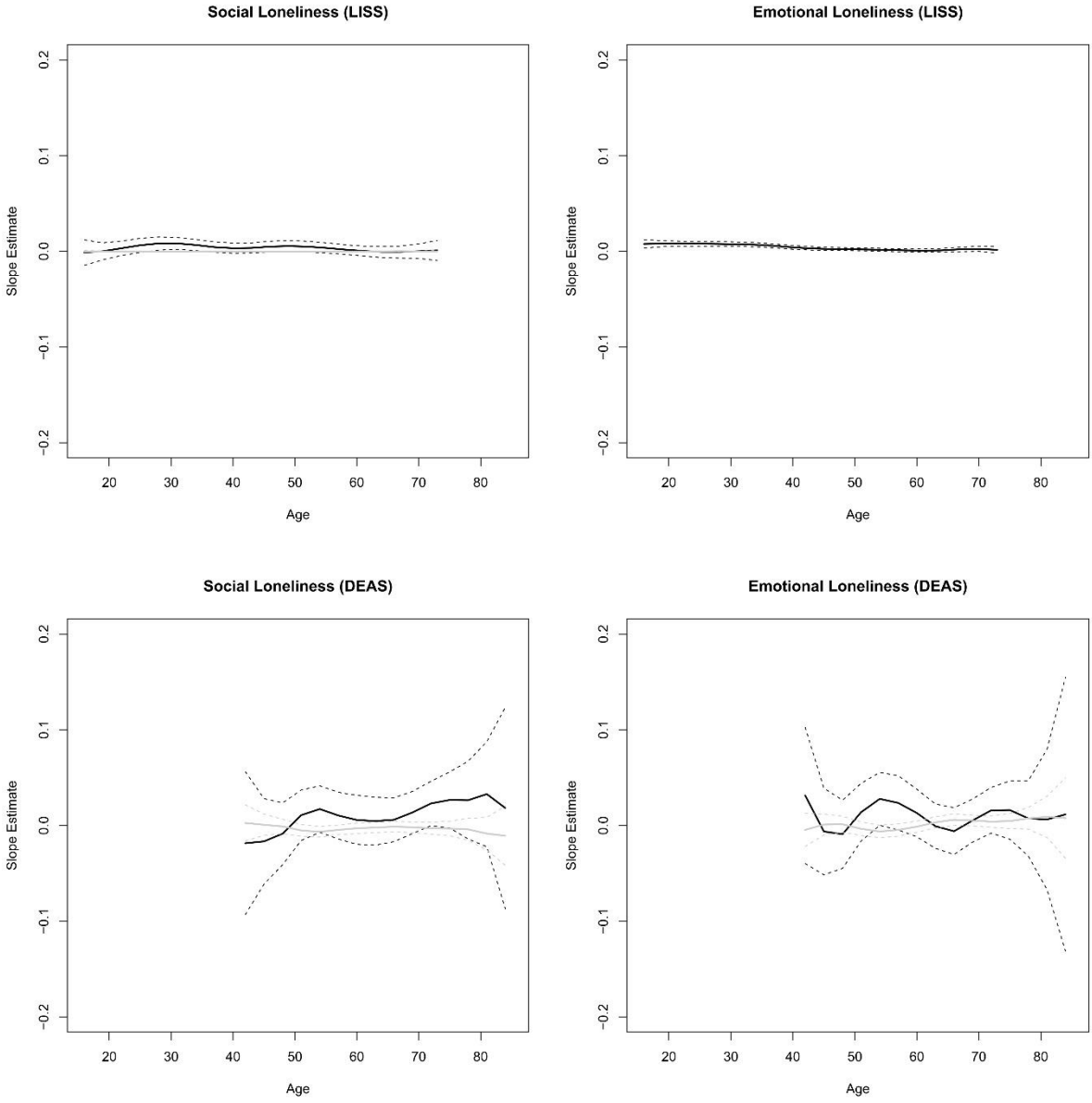
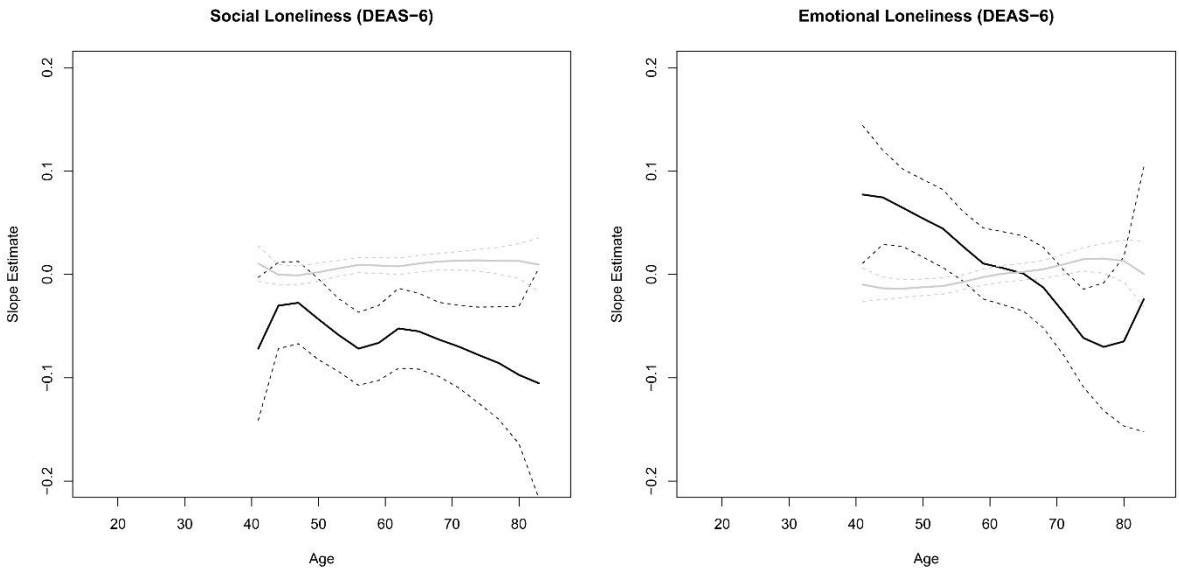


Figure S10 (continued)



Note. The figure displays near-zero point estimates of linear (change rates) and quadratic (changes in change rates) slopes derived from the scalar invariance model, in which the means of latent intercepts and slopes were allowed to vary as a function of age. Estimates are shown for a series of focal age points and do not represent developmental trajectories over time. Black lines indicate linear slopes, and grey lines indicate quadratic slopes. Solid lines represent point estimates; dashed lines indicate 95% confidence intervals (±1.96 SE). No quadratic slope was estimated for emotional loneliness in the LISS dataset.